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Form Work for Sloping Bottoms of Concrete Tanks

Estimated Pressures on Forms — Pressures Assumed for Forms of Sloping Tank Bottoms—Barrels of Water Resist Upward Pressure

By J. W. WYNN
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In building sewage treatment plants and similar works the contractor has a problem in concrete pressures which is quite different from that ordinarily met with in designing forms. Many of these plants have tanks with sloping bottoms of concrete placed on the ground, which require forms on the upper side. The forms for the entire bottom are set before depositing concrete, and weights must be used to counter-balance the vertical component of the maximum pressure which will exist at any one time.

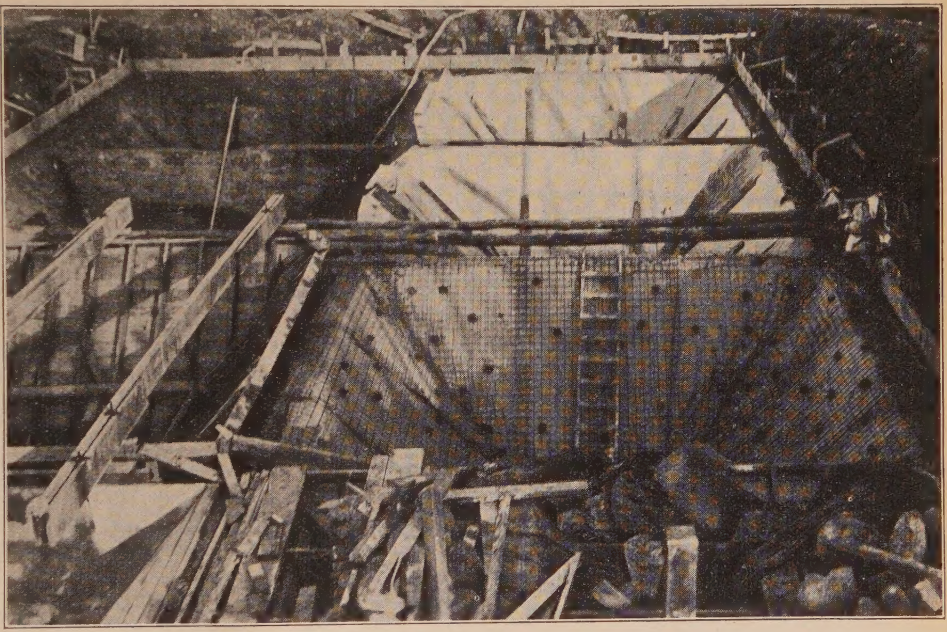


Figure 1. Tank bottoms in various stages of construction

The proper solution of this problem not only involves the question of maximum unit pressures at various depths with given rates of placing, but of pressures which may exist both above and below the maximum.

Major Shunk's experiments, which have been widely quoted, were made by means of a pressure board 9.23 in. in diameter, set in the side of a form for a large mass of wet, lean concrete. This mix was 1:3:5½ and the consistency was such that workmen walking in the concrete sank down about 18 inches. According to these experiments, the maximum horizontal pressure per sq. ft. $P = WH$, where $W = 152$ lb. and $H =$ height in feet to which the concrete has been deposited in a time T. The time $T = C \div \frac{150}{R}$, where C is a constant depending on the temperature of the concrete and $R =$ rate of placing in the vertical feet per hour. The constant C for various temperatures is as follows:

Temperature (deg. F.)	80	70	60	50	40
Value of C	20	25	35	50	70

One construction company of large experience states that their form design is based upon a fluid pressure of 145 lb. per cu. ft., and upon the assumption that the maximum pressure will occur in one hour. Most companies design for a fluid pressure of from 125 to 150 lb. per cu. ft. except for walls which will be filled gradually, where they design for a maximum of 750 lb. per sq. ft. These rules work out satisfactorily in practice, but they are not conclusive evidence of the actual pressures and, of course, they do not give any indication of pressures that exist below the point of maximum.

It was found that the use of a pressure board to measure pressures in walls where the concrete was mixed 1:2:4 with a slump of from 4 to 6 in. gave very low results. In such mixtures friction, arch action, a certain amount of cohesion and resistance to shear introduce serious errors. The best data we have are obtained by the use of the soil pressure cell developed by the U. S. Bureau of Public Roads.

The paper given by Earl B. Smith before the American Concrete Institute and published in the Proceedings of that society for 1920, give test data for 1:2:4 concrete of quaky consistency for several rates of placing. From a study of these curves it appears that differences in temperature between 65 and 80 deg. F. are not important and that between rates of placing of from 1.7 and 7.4 ft. per hour the maximum pressure does not exceed 275 lb. per sq. ft. For the lower rate of placing the maximum pressure was about 250 lb. per sq. ft., and it was reached in about 1½ hours at a head of approximately 2 ft. 6 in., indicating an equivalent fluid pressure of 100 lb. per cu. ft.

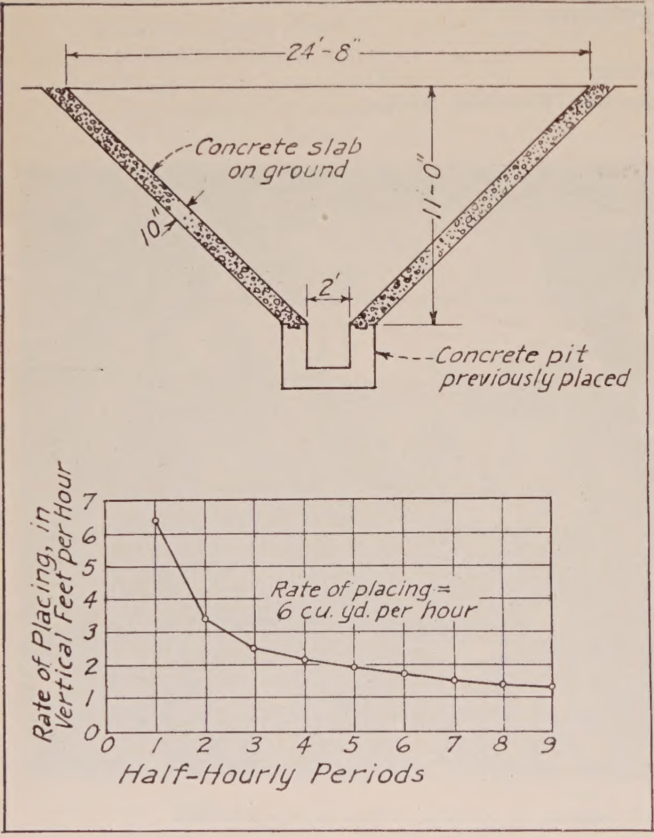

24'-8"
Concrete slab on ground
10"
11'-0"
2'
Concrete pit previously placed
Rate of Placing, in Vertical Feet per Hour
0
1
2
3
4
5
6
7
Rate of placing = 6 cu. yd. per hour
0 1 2 3 4 5 6 7 8 9
Half-Hourly Periods

Figure 2. (Above) Section through large tank bottom. (Below) Average rate of placing, in vertical feet per hour, during each half-hour period

For the higher rate of placing the maximum pressure was 275 lb. per sq. ft., reached in approximately 30 minutes at a head of 3.3 ft., indicating an equivalent fluid pressure of 85 to 90 lb. per cu. ft. maximum. From the maxima the pressures fell off rapidly, but the evidence is not clear as to when all pressure stopped, although it seems probable that it dropped to one-half maximum within a period equal to the time required to reach the maximum.

Experiments with Soil Pressure Cells

Technologic Paper No. 175 of the U. S. Bureau of Standards gives experiments by Slater and Goldbeck on form pressures, made by soil pressure cells. The concrete mix was 1:⅔:1⅓. The coarse aggregate was gravel graded from ¼ to ½ in. The amount of water used was 12½ per cent of the combined weight of the dry materials. These tests showed a maximum equivalent fluid pressure of 124 lb. per cu. ft. The curves given show that for rates of placing of 5 ft. and 6 ft. per hour the maximum pressure occurred in about 30 minutes and that there was zero pressure within 150 minutes. Two of the cells were placed so that they registered vertical upward pressure. They showed smaller pressures and reached maximum and zero sooner than the cells measuring lateral pressure. The forms were vibrated by the use of hand hammers.

Teller Tests of Effect of Vibration

Tests made by the Bureau of Public Roads at Arlington, Va., in 1930, as reported by L. W. Teller, senior engineer of tests, showed pressures for 1:2:4 gravel concrete of different slumps and the effect of hand spading and vibration. It was indicated that moderate changes in temperature between 50 and 75 deg. F. did not greatly affect the results. With a rate of filling of about 20 ft. per hour the maximum pressure for hand-tamped concrete was about 900 lb. per sq. ft. for 3½-in. slump and 1,100 lb. per sq. ft. for 7½-in. slump. The first occurred in about 17 min. at a head of 5½ ft.; the second in about 25 min. at a head of 8½ ft. The equivalent fluid pressures were approximately 165 lb. and 130 lb. per cu. ft., respectively. It took approximately 35 min. to fill the forms; at the end of one hour thereafter the maximum pressure was under 300 lb. per sq. ft., and at the end of two hours it was between 150 and 220 lb. per sq. ft.

Application to Sloping Tank Bottoms

It is realized that the available best data are quite meager and that any results might be misleading on account of the great number of factors influencing them. Some of the more important of these factors are probably the kind of cement and aggregates, the mix, the slump, the method and rate of deposit, and the temperature. However, the following assumptions might not appear unreasonable for hand-tamped concrete mixed 1:2:4 with gravel aggregate, with a slump of 4 to 6 in., a rate of placing of 1 to 2 ft. vertically per hour, and a temperature 60 to 70 deg. F.

1. Maximum pressure will occur in about 1½ hours.
2. Maximum pressure will be about 200 lb. per sq. ft.
3. The pressure at the end of 3 hours will be 100 lb. per sq. ft.
4. The pressure at the end of 4 hours will be zero.

Proceeding on the basis of these assumptions to the calculation of weights for the forms for sloping tank bottoms, the largest size tank is 24 ft. 8 in. square inside at the top and 2 ft. square inside at the bottom. The vertical height is 11 ft. The concrete slab is 10 in. thick perpendicular to the slope. There are about 28 cu. yd. of concrete to be placed in 4½ hours. Basing computations on the assumptions made in the preceding paragraph, one-third of the tank will have an average pressure of 100 lb. per sq. ft., one-third will have an average of 150 lb., one-quarter will have an average of 50 lb., and there will be no pressure on the remainder. These pressures are equivalent to an average of 95 lb. horizontal pressure for the entire tank. The vertical component was assumed to be seven-tenths of the horizontal. In 4½ hours the concrete would be placed over a horizontal area of 604 sq. ft. and the total upward thrust would therefore equal 604 × 0.7 × 95 = 40,200 lb.

Use of Weights to Resist Upward Pressure

The actual weights used for one tank were the forms, which were calculated to weigh about 10,000 lb., including braces and runways, 12 barrels filled with water at 450 lb. each, and six pieces of concrete pipe at 1,050 lb. each—a total of 21,700 lb. The uplift was only about ¼ in. The average rate of placing was slightly under 6 cu. yd. per hour. The mix was 6½ sacks of cement, 1,200 lb. dry sand, 1,900 lb. dry 1-in. gravel, and 38 to 40 gallons of water per cu. yd. The slump was from 5 to 6 in. Concrete was dumped from buggies and spaded by hand. The temperature was about 54 deg. F. and the concrete was heated to about 70 deg. for the first hour or more. Tests of the cement showed time of initial set ranging from 3 hr. 10 min. to 4 hr. 10 min., and time of final set from 6 hr. 10 min. to 6 hr. 55 min.

For these larger tanks it was found that a total loading of 24,000 lb. was fairly satisfactory. This is equivalent to 44½ lb. per sq. ft. of horizontal area.

Rates of Placing

On this tank it was observed that after placing about 7 cu. yd. the weight of the forms and water above just about offset the uplift of the concrete. This yardage filled a section of form with a horizontal area of 165 sq. ft. and a vertical height of about 5 ft. 6 in. The rate of placing was, of course, variable, but it averaged about 6 ft. vertically for the first half hour and 3 ft. for the last hour. Assuming that the horizontal pressure would be 250 lb. per sq. ft. as a maximum and would decrease to 100 lb. at the bottom, the average would be about 150 lb. The total upward pressure expected on this basis would, therefore, be 165 × 0.7 × 150 = 17,325 lb. Since the forms and water weighed about 15,400 lb., it is seen that the estimated uplift for this lower section is very much closer to the actual than it is for the tank as a whole.

There were also tanks of a smaller size, measuring 20 ft. square inside at the top and 2 ft. square at the bottom, with a height of 9 ft. from top to bottom. The slabs were 10 in. thick, like the larger tanks. It took only about 3 hours to place concrete on these slopes at the rate of 6 cu. yd. per hour. It was assumed that the maximum horizontal pressure on the completed tank would be 200 lb. per sq. ft. and the remaining pressure at the bottom would be 100 lb. One-half of the tank would then exert an average pressure of 100 lb. and the other half an average of 150 lb. The upward force would then be 396 × 0.7 × 125 = 34,650 lb.

On these smaller tanks the forms weighed approximately 7,500 lb. and it was found that an equivalent of about 10,000 lb. in weights was required in addition. A total loading of 17,500 lb. seemed to be sufficient in most cases to prevent any rise in the forms that would be objectionable, but it was necessary at times to stop concreting for a short period to prevent too much movement. This loading was equal to slightly more than 44 lb. per sq. ft. of horizontal area.

Avoid Concrete That Is Too Stiff

The men on the job seemed to feel that the slump and temperature of the concrete were the most important factor in holding the forms in position with the weights used. The concrete cannot be successfully handled if it is too stiff, because of difficulty in placing and tamping. The concrete surfaces were found in fine condition after stripping. Hardly any patching was required. The concrete aggregates and the mixing water were heated so that the temperature of the concrete in the buggies was between 70 and 85 deg. F. The concrete deposited during the first hour or two was kept quite hot. The air temperature was generally between 40 and 50 deg. F. when this work was being done.

Factors in Pressure

It seems very probable that both temperature and slump are important factors in the pressures to be expected; but in making the theoretical calculations given above they were taken into consideration by using data from the best test results available for concrete of moderate slump and for approximately the same range of temperature.

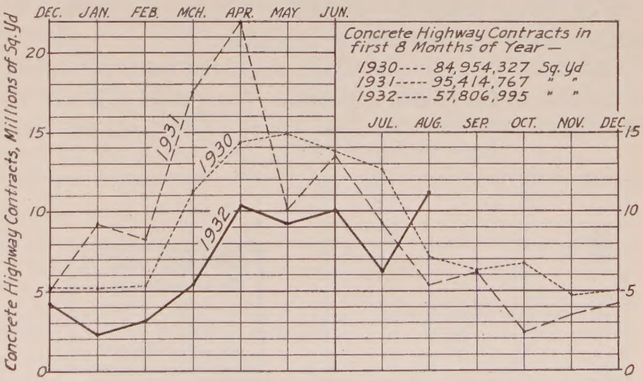
It is hoped that other contractors and engineers will publish data giving their experience with forms for similar tanks or other sloping concrete surfaces, for there does not seem to be much information available on the subject.

Concrete Road Awards in August Show Large Increase

Deferred Work in Highway Programs Being Contracted—R. F. C. Funds Showing Effect

One of the most encouraging events affecting the construction industry in recent months is the award of contracts, during August, for a total of 11,136,778 sq. yd. of concrete roads throughout the United States.

This is the largest monthly total for this year, and is far above the average monthly award of 7,225,874 sq. yd. for the first 8 months of 1932, according to figures compiled by the Portland Cement Association. The recent August total is nearly twice the figure reported for August, 1931, and it is 5 million square yards in excess of July, 1932, thus reversing the usual downward trend at this time of year. The normal yearly trend is well represented in the chart in the curve for 1930.



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The good showing for August is in considerable part a reflection of federal aid from the fund of 120 million dollars provided in the Federal Relief Act; but it is also a reflection of a changed attitude in state highway departments.

Simplified Control of Ready-Mixed Concrete

Simple Methods of Designing the Mix—Control and Operation of the Plant Without Constant Determinations of Moisture in the Aggregate

By D. V. TERRELL
Professor of Civil Engineering, University of Kentucky, Lexington, Ky.

READY-MIXED concrete is rapidly finding an important place in the building material field. Plants are being erected in all parts of the country. The ultimate success of this material will depend on how well the operators do their work and to what degree of honesty the concrete wanted by the purchaser is actually furnished by the producer.

When the public has been educated to buy ready-mixed concrete of a given strength and consistency it will be important that the operator furnish the customer exactly what he wants. At the same time the operator must know how much material he will use to produce a cubic yard of concrete such as the customer desires.

Must Meet Requirements Specified

Let us suppose the customer orders 6-in. slump concrete to test 3,200 lb. per sq. in. at 28 days; or the customer may specify 6.2 bags of cement per cu. yd. of concrete with a 4-in. slump. In either case the operator must know how much cement, water, fine and coarse aggregate will be required to make a cubic yard of concrete.

There are a good many variables that will affect the amount of materials required for the above conditions, which include the brand of cement and the type and gradation of fine and coarse aggregate.

Since most of the ready-mix plants deal with materials that are fairly constant, it is a simple process to set up two charts and by calculation work out the values for any class, strength and slump desired.

Development of Design Charts

With given materials, determine the specific gravity of surface-dried fine and coarse aggregate.

Determine by trial and observation the ratio by weight of the fine to the coarse aggregate. For gravel this will be from 34 to 38 per cent fine and for stone 38 to 42 per cent. A reasonable figure to use for gravel is 36 per cent and for stone 40 per cent. In almost all cases these percentages will produce workable concrete.

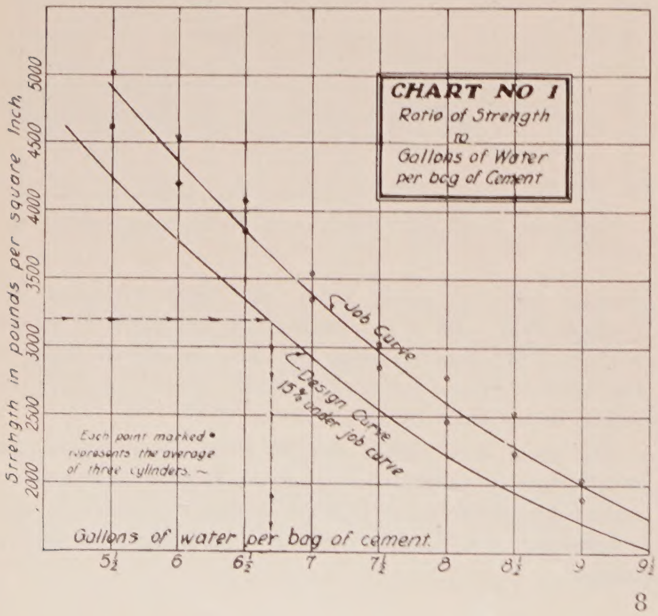
Design the various mixes, using from 5½ to 9½ gal. of water per bag of cement, letting the variable be ½ gal. We now have nine different mixes. Each mix should be worked out for a 2-in. and a 6-in. slump. Using three cylinder batches, we will have 54 concrete cylinders 6 by 12 in. in size for the test. All of the cylinders are to be made, cured, and tested according to standard methods.

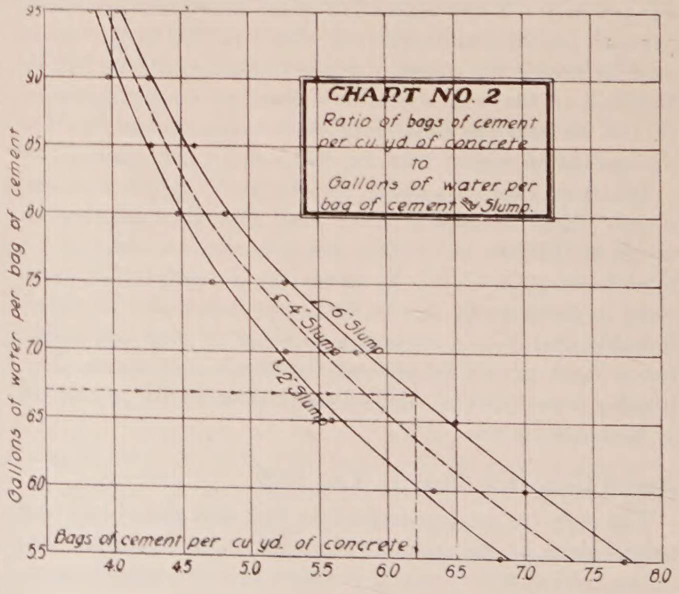
The following information should be worked out and tabulated:

(a) Bags of cement per cubic yard of concrete.
(b) Slump of concrete.
(c) Gallons of water per bag of cement. (Water added plus free moisture in aggregate.)
(d) Average strength of 3 cylinders at age of 28 days.

With the above values Charts No. 1 and No. 2 can be plotted.

Chart No. 1—This chart shows the ratio of strength to the gallons of water used per bag of cement. There will be two points on each ½-gal. line, each point representing the average of three cylinders. The job curve line is then drawn and should show a fairly consistent curve. The





design curve is calculated, being placed 15 per cent under the job curve. This is in accordance with the American Concrete Institute's specification.

Chart No. 2—The second chart shows the ratio between the number of bags of cement per cubic yard of concrete, the slump, and the gallons of water per bag of cement. Each point is plotted and the 2-in. and 6-in. slump lines are drawn. The 4-in. slump line is drawn half way between the 2-in. and 6-in. lines, which is sufficiently accurate for the operation. With these two charts we are now in position to make a calculation of the material required for a cubic yard of any strength and consistency of concrete desired.

Let us assume that the material to be used has the following values:

(a) Cement, solid, volume of one bag, 0.485 cu. ft.
(b) Sand, specific gravity, 2.62.
(c) Crushed stone, specific gravity, 2.68.
(d) Ratio of fine to coarse, 40-60.
(e) Average combined specific gravity = 2.656.

Illustrative Problem

The material required for a cubic yard of 6-in. slump concrete, to test 3,200 at 28 days, may then be determined.

With Chart No. 1 follow the 3,200 line to the design curve, then vertically down, and read 6.7 gal. of water per bag of cement.

Enter Chart No. 2, and entering at the left with 6.7 gal. of water, follow horizontally to the 6-in. slump curve, then vertically downward, and read 6.2 bags of cement per cu. yd. of concrete.

By the solid volume theory the total weight of surface-dry fine and coarse aggregate per cu. yd. of concrete equals—

$$27 - \left[\left(0.485 + \frac{\text{Gal.}}{7.48}\right) \times \text{Bags}\right] \times 62.4 \times \text{Ave. Comb. Sp. Gr.}$$

In the problem, by substituting the values found, we have—

Gallons of water = 6.7.
Number of bags = 6.2.
Ave. Comb. Sp. Gravity = 2.656.

From the substitutions the equation becomes—

$$27 - \left[\left(0.485 + \frac{6.7}{7.48}\right) \times 6.2\right] \times 62.4 \times 2.656 = 3{,}055.8$$

The required quantity of surface-dry coarse and fine aggregate is, therefore, 3,055.8 lb., or 3,055 lb.

Since the ratio of the fine to the coarse was taken as 40-60, the required weight of surface-dry sand is 3,055 × 0.40, or 1,222 lb. Similarly, the required weight of coarse aggregate is 3,055 × 0.60, or 1,833 lb.

Total free water required for one cubic yard of concrete is equal to 6.7 × 6.2 = 41.54 gal.

Therefore the total amount of material required for one cubic yard of concrete as specified in the problem is 6.2 bags of cement, 1,222 lb. of surface-dry sand, 1,833 lb. of surface-dry stone, and 41.54 gal. of water.

Application to Plant Operation

Let us now apply the above to the mixing and control of concrete without keeping a constant check on the free moisture in the aggregate. The only way that water reaches the concrete is from the water added to the mix, and through the free moisture in the aggregate, which forms a part of the mixing water. Sand is nearly always damp and will contain from 2 to 6 per cent of free moisture. The coarse aggregate may be entirely dry or it may contain as much as 3 per cent of free moisture. Therefore, provision should be made at the plant to keep all aggregate damp before being used. This can easily be done with a sprinkler system. Care must be taken not to overwet the aggregate to such a point that the water will drip from the bins.

An average figure can be assumed for the percentage of free water in the aggregates, a fair figure being 3 per cent for the fine aggregate and 0.5 per cent for the coarse aggregate. If we calculate the amount of damp material needed for a cubic yard of concrete as given in the illustrated problem, we have $\frac{1{,}222}{0.97} = 1{,}260$ lb. of damp sand, of which 38 lb. is water; and we have $\frac{1{,}833}{0.995} = 1{,}842$ lb. of damp stone, of which 9 lb. is water.

We then have the same amount of surface-dry aggregate but we have added 38 + 9 = 47 lb. of water, which is equal to $\frac{47}{8.34} = 5.63$ gal. of water. Subtracting from the water calculated, we have 41.54 — 5.63 = 35.91 gallons to add. Therefore, for a cubic yard of concrete on the basis of the given problem we have 6.2 bags of cement, 1,260 lb. of damp sand, 1,842 lb. of damp stone, and 35.91 gal. of water to add.

A similar calculation can be made for any strength, grade and consistency of concrete desired, ranging in strength from 1,500 to 4,500 lb. per sq. in., and in slump from 2 to 6 in. The results may be put in table form for convenience.

Operation of the Plant

An order is given to furnish concrete of any given strength and slump. As in the illustrative problem, assume 3,200 lb. per sq. in. at the age of 28 days, with a 6-in. slump. From the table the values such as given above may be quickly looked up, or a calculation such as given in the illustrative problem can be made.

First: Place into the mixer the required amount of cement, sand and coarse aggregate.

Second: Add the water to within 3 gal. of that shown by the final calculation, or as given in the table.

Third: Run the mixer the required length of time. Examine the concrete for consistency or slump. If the slump is too low, add from the 3 gal. of water left out, enough to produce the required slump.

Fourth: For each gallon of water left out, add 14 lb. of coarse aggregate and 9 lb. of sand.

Fifth: Should the mix require more water than shown by the final calculations or as given in the table, add enough water to produce the required slump.

Sixth: For each gallon of water added above that shown by the final calculation, leave out 14 lb. of coarse aggregate and 9 lb. of sand.

The first few batches sent out will be used as trial batches, after which there should be no trouble in keeping the concrete of uniform consistency.

(*Continued on Page* 20)

Extend Height of Building With Light-Weight Concrete

Precast Concrete Roof Slabs and Fireproofing of Steel Frame Utilize Waylite, a Refined Slag Aggregate — Fines Have Cementing Value

THE erection of a fifth story to the building occupied by the Rapid Roller Company, at 26th and Federal streets, Chicago, is being made possible through the use of a light-weight concrete aggregate, not only for the fireproofing of steel columns, beams and girders, but also for the precast concrete roof slabs.

A Refined Slag Aggregate

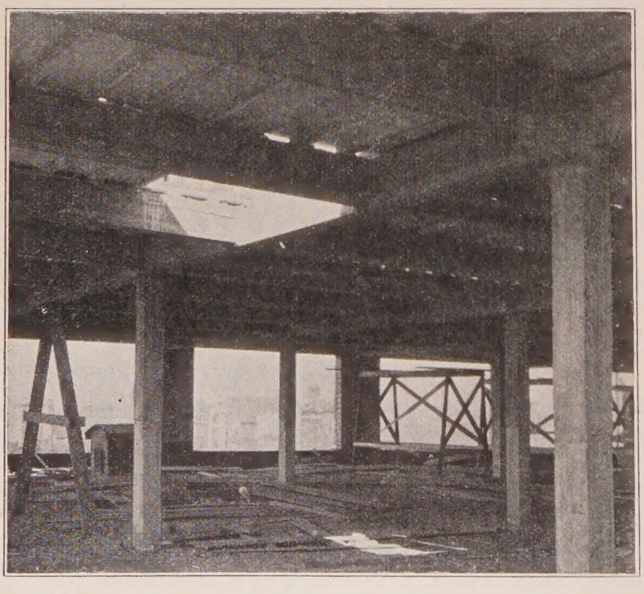
The material being used for both fine and coarse aggregate is the new refined blast-furnace slag product known as Waylite, manufactured in a plant in South Chicago. This product is made by running molten slag direct from the blast furnaces into a huge centrifuge, where it becomes expanded as a result of treatment in an atmosphere of steam. The resulting product, of light-weight and from white to light buff in color, is impregnated with non-communicating cells.

Holding Down the Dead Weight

The fifth story added to the Rapid Roller Company building has a floor area of 12,000 sq. ft. The light-weight aggregate just described was selected by the architect for the purpose of holding down the dead weight and thereby keeping the column and footing loads in the existing structure within the limits permitted by the city building regulations.

Weight of Concrete

The concrete used for the fireproofing of steel columns, beams and girders is a mixture of 1 part of ordinary portland cement and 6 parts of the combined volumes of fine and coarse Waylite. The resulting concrete had an average weight of 103 lb. per cu. ft. The aggregate was delivered by truck, direct to the concrete mixer, from the plant where it is produced.



Light-weight aggregate employed in fireproofing and precast concrete roof slabs

The precast concrete roof slabs, as previously stated, were made of the same aggregate, both fine and coarse, as that employed in the fireproofing. The weight of the concrete in these precast slabs averaged 97 lb. per cu. ft. The slab units are 18 in. wide and 8 ft. long, and are reinforced.

Acknowledgments

The concrete fireproofing of the steel columns, beams and girders was placed by the general contractor, the A. and E. Anderson Company, of Chicago, and the precast concrete roof slabs were placed by the U. S. Gypsum Company, of the same city. The architect on this addition is L. M. Mitchell, of Chicago. The light-weight aggregate was produced and supplied by the Chicago Waylite Aggregate Company, of which Harvey C. Adams is president and J. A. Quillinan is sales manager.

Fines Have Cementing Value

An interesting and entirely logical feature of this new slag aggregate has been observed in tests thus far conducted by and in behalf of the manufacturer. This feature is seen in the cementitious property of the fines. Indications are that this property is due to the fact that the fines are produced in an anhydrous condition, thus possessing cementitious value so long as the aggregate is kept dry. This may account for the fact that, with the use of ordinary portland cement, the 7-day strength of the concrete is averaging about 80 per cent of the 28-day strength. Further and more detailed investigation is being made of this feature, and results will be reported if information of interest to users of concrete is developed.

Ready-Mixed, Material Groups' Meetings and Exhibit

The National Ready-Mixed Concrete Association and two of the material producing groups will hold their annual meetings practically simultaneously in Detroit next January, in conjunction with the highway and building congress. All will have headquarters at the Book-Cadillac, where one joint exhibit will be held.

The ready-mixed concrete group will meet on January 18, the National Sand and Gravel Association on the 17th and 18th and the National Crushed Stone Association from the 16th to the 18th.

Co-ordination of Basic Principles of Concrete Mixtures

Review of Research in Concrete Mixtures Beginning with Year 1914, Is Included in Sixth Article of Series—First Definite Advance in Technology

VI—Needed Laws of Mixtures and Known Fundamentals (Continued)

By JOSEPH A. KITTS
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The previous chapters reviewing concrete mixture research give an index of the state of the knowledge of mixtures up to the year 1914. There was no generally accepted basis of measure of proportions; no complete idea of basic mix structures; no satisfactory measure of consistency, plasticity, workability or flowability of mix; no formulas or laws of cement content, of water content, of aggregate content and grading, for a given strength and flowability of mix; no qualitative unit of measure of the screen analysis and grading of aggregate particles; no expedient algebraic means of determining proportions for the grading of aggregate sizes; no co-ordination of the important fragmentary known fundamentals of mixtures; and no accurate process of practical concrete making. The published data of individual concrete mixture tests were not sufficiently complete in characteristics of the ingredients, unit water content, unit cement content, grading, manner and time of mixing, method of curing, resulting density, weight, yield, or workability, and were generally barren of true cause and effect. The physics of materials and mixtures, the technique of testing, and the limitations of test measures and of synthesis, were not adequately known. There was little appreciation that "concrete" embraced a multitude of products and that the making of proper concretes for modern structures is, necessarily, a strictly scientific technological process. The effects of mixing time, and of moisture, temperature and age of curing, were not definitely known. The effects of water content on the strength and density of the mix were neither agreed upon nor approximately known. Sloppy wet mixtures vs. plastic wet mixtures vs. dry, stiff, old style mixtures, were mooted by equal authority. Arbitrary proportions were the general practice, with Synthesis, Void Theory and Fuller Grading as the exceptional partly scientific methods of proportioning—none fully adequate.—The Author.

At the beginning of the year 1914 a serious state of affairs existed in the field of concrete, as portland cement production in the United States had increased from 82,000 bbl. for the 10-year period 1870-1880 to 92,000,000 bbl. in the year 1913, but there was no technology of concrete-making keeping apace with the demands entailed by this vastly increasing use of cement and concrete. In this situation, the Portland Cement Association, which had assumed an increasing responsibility in concrete research from 1904 to 1914, acting in co-operation with Lewis Institute, which had established the Structural Materials Research Laboratory at Chicago, began comprehensive researches which were continued at the Institute until 1926. These activities and the personnel were then transferred to the laboratory of the association in its new headquarters building in Chicago.

Portland Cement Association-Lewis Institute Co-operative Research

The co-operation of the Portland Cement Association and Lewis Institute at the Structural Materials Research Laboratory, from 1914 to 1926, under Duff A. Abrams as professor in charge, resulted in the most valuable, comprehensive and definite fund of data and knowledge of concrete and concrete mixtures made available theretofore. The important work done is a criterion of the value of co-operation of manufacturers to improve the uses of their common product, and also an example of the value of co-operation of an engineering college with a manufacturing industry in the research studies of a product for engineering use.

The physics of concrete mixtures had previously proved a most abstruse subject, owing to the many variables involved in a concrete mix and the elusiveness of a fundamental starting point. Research data had been contradictory. Facts had not been distinguished from opinions. The ancient rudimentary bulk volume measure of ingredients was the mental concept of the basic measure, as it had been down the ages. The fact that anyone could make concrete of a sort, by mixing rock particles, cement and water, opposed the employment and incentive of modern thought as applied to portland cement making and to the many other products of modern science in common use.

A Huge Task Recognized

The huge task of experimental exploration confronting Professor Abrams was not comprehended in 1914; it is more fully, but not near completely, known today. However, with wise foresight that the task was a large one and would require ten years or more, the laboratory was provided with all necessary equipment for both physical and chemical experiments, the research activities were expanded until a staff of more than 30 engineers and assistants was engaged in the studies of properties of concrete materials and mixtures, and a comprehensive program of experiments was conducted, the tests amounting to some 45,000 or more per annum.

The results of the investigations at the Structural Materials Research Laboratory have been published in some nineteen or more circulars and bulletins of the laboratory, and through many prepared papers and discussions before various technical societies, by Duff A. Abrams, Oscar E. Harder, Stanton Walker, Harrison F. Gonnerman, Albert Timms, C. L. Ford, Claude L. McKesson, Franklin R. McMillan, and others. A list of these research papers and publications is found in the report of the director of research, Portland Cement Association, for the year ending November, 1928. These papers contain very comprehensive data on concrete tests, which are more nearly complete than any data theretofore, and offer solutions to most of the questions of concrete physics when thoroughly classified and analyzed from the new points of view established by the initial analyses and the accumulating understanding derived from such progressive analyses. These data will require the prolonged work of many analytical minds to thoroughly sift out the important facts contained in them.

Professor Abrams' Developments

The Abrams developments of major importance in concrete physics are: (1) the water-cement ratio strength law and its application; (2) the adoption of a uniform ratio of sieve sizes in screen analysis, resulting in the discovery of the fineness modulus principle; (3) the fineness modulus of aggregates, its meaning, proper values, and application in proportioning various characters of fine and coarse aggregates; (4) a mixing water equation for concrete of various consistencies; (5) the development of the slump test as a measure of plasticity of concrete; and (6) the mathematical and graphical co-ordination of these developments and the empirical data of strength and slump, providing a method and data tables for formulating mixtures of any predetermined practicable strength and slump with various maximum sizes and types of aggregates.

These developments were first published in the minutes of the annual meeting of the Portland Cement Association, December, 1918, and reprinted as *Bulletin* 1, Structural Materials Research Laboratory, Lewis Institute, in "Design of Concrete Mixtures," by Duff A. Abrams (1919). The most complete development of the Abrams method is given in "Design and Control of Concrete Mixtures," Second Edition (January, 1927), published by the Portland Cement Association.

The Water-Cement Ratio Strength Law

The Abrams water-cement ratio law of strength of concrete is expressed by the equation

$$S = A/B^{w/c} \quad . \; . \; . \; . \; . \; . \; . \quad (21)$$

in which S is the compressive strength (lb. per sq. in.) at a given age, w/c is the ratio of volume of mixing water to bulk volume of cement (94 lb. = 1.0 cu. ft.), and A and B are constants given as dependent (1) on the age of the concrete, (2) on quality and character of the aggregate and cement, (3) on the fineness of grading of the aggregates, (4) on time and efficiency of mixing, (5) on moisture and temperature of curing, and (6) on skill of technological control.

This relation is stated to be perfectly general for a given aggregate and cement and condition of manipulation so long as the mix is plastic and workable. For plastic and workable concretes of normal standard (1927) portland cement, and rounded gravel aggregates of standard quality, machine mixed one minute and cured and tested under standard requirements, the values of A and B (Eq. 21) for skilled and ordinary proportioning control are given as follows, for concrete 28 days old:

	A	B
Skilled control	14,000	7
Ordinary control	14,000	9

The practical mathematical form of the equation is—

$$\log S = \log A - w/c \log B \quad . \; . \; . \; . \quad (21a)$$

and, therefore, is a "semi-log" curve and may be shown graphically as a straight line by plotting the strength to logarithmic scale, as ordinate, and water-cement ratio to natural scale, as abscissa.

First Definite Advance in Concrete Technology

This is the first well established and most general definite expression of the strength of mixtures; has provided an essential element of concrete technology previously lacking, and is adequately accurate when employed with technological skill in proper relation to cement content, fineness modulus and grading. As such it is a revolutionary discovery and the most important single development in the physics of qualities, as distinguished from the physics of quantities expressed by the Feret law of combination by absolute volume, Equation 10. It supplements all prior as well as subsequent methods of proportioning, and has, therefore, given an impetus to the development of an adequate concrete technology.

The proper and more generally correct expression of the ratio is based on the volume of water to the unit absolute volume of cement. However, only slight error is involved in the ratio of cubic feet of water to 94 lb. of portland cement, since the specific gravity of portland cement is practically constant.

The equation of the water-cement ratio strength law involves two unknowns, the quantities of water and cement, and, therefore, is incomplete in itself. It has this and other limitations of application which will be presented in later chapters.

The Abrams water-cement ratio strength law, with limitations, satisfies our Requirement (2) when Requirement (1) is known.

Sieve Ratio and Fineness Modulus of Aggregates

The adoption of a uniform ratio of sieve openings, by Professor Abrams, has resulted in the first basic physical measure of the size-grading of an aggregate—the fineness modulus—which is a physical characteristic measure obtained mechanically by screen analysis, and one sufficiently accurate to satisfy a highly important essential in concrete technology.

A uniform ratio series of sieve openings was introduced for ore dressing by P. R. von Rittinger in 1867, and, subsequently, other uniform ratios were designed by Prof. R. H. Richards, W. S. Tyler Co., Institution of Mining and Metallurgy, and Prof. T. J. Hoover. Advantages of the various uniform ratio screen scale sieves were brought to the attention of testing engineers by G. A. Disbro, in a paper thoroughly presenting the subject in *Proceedings,* A. S. T. M., Vol. XIII, 1913. (Nearly half a century was required to adapt the valuable technique of one industry to another!) Prior to 1931 aggregate screens were designated by mesh to the inch, without particular regard to the size of openings or ratio of meshes or openings, and both round hole and square hole were employed.

The Tyler standard series starts with the No. 200-mesh sieve having a square opening of 0.0029 in. or 0.074 m.m. (previously standardized by the U. S. Bureau of Standards for cement testing) and the successive size openings are in the ratio of $\sqrt{2}$, or 1.4142. Prof. Abrams adopted the alternate sizes, of the Tyler standard sieves, having an opening ratio of 2.0, commencing with the No. 100, having a square opening of 0.0058 in. or 0.147 millimeters.

It had been customary, in the screen analysis, to note the percentages of the material passing (or finer than) given screen sizes, while Prof. Abrams gave consideration to the percentages of the whole aggregate retained on (or coarser than) each of the sieves. The sum of these percentages, retained on the screen scale of uniform ratio, was found to give a value which was a function of the average diameter of particles. This measure was called the "fineness modulus." It could have been appropriately called "coarseness modulus," as the value increases with the coarseness.

Fineness Modulus

The fineness modulus of an aggregate is the sum of the proportions, of the total absolute volume of aggregate tested, coarser than each of the Tyler standard sieves Nos. 100, 48, 28, 14, 8, 4, ⅜-in., ¾-in., 1½-in., 3-in., etc. It is a logarithmic function of the average diameter of particles and, likewise, of the surface area of particles. The relation between the modulus and the average diameter of particles, for the Abrams screen scale series, is expressed by the Abrams equation—

$$f = 7.94 + 3.32 \log d'' \quad . \quad . \quad . \quad . \quad . \quad (22)$$

in which f is the fineness modulus of the aggregate, d'' is the average diameter of particle (by square opening measure in inches), and logarithms are to the base 10. It is an index of grading of particle sizes only in so far as it indicates the average diameter; particles may be one particular size or a varying number of sizes for a given fineness modulus. However, when combining a fine aggregate (sand) with a coarse aggregate (rock) the modulus then becomes an index of the coarseness of grading. When the various sizes of the aggregate have the same apparent specific gravity the proportions by weight (instead of by absolute volume) may be employed to determine the modulus.

A fine and a coarse aggregate may be combined, by simple proportion, for any fineness modulus between the moduli of the two aggregates. The parts, and the whole, of any theoretical or empirical grading curve, such as the Fuller grading, have particular fineness moduli. The fineness modulus, therefore, is a useful physical measure in any method of grading and can be employed algebraically with ease and speed in place of the slow and tedious trial proportions and graphical method. Where three or more sizes of aggregates are employed in the mix, a grading curve is an essential adjunct of the fineness modulus.

The "maximum permissible fineness modulus" (better called the optimum fineness modulus) is shown by Prof. Abrams to increase with maximum size of the aggregate and cement content, and to be higher for rounded gravel aggregates than for irregular shaped particles. These maximum values, for various proportions of mix and maximum sizes of aggregates, are given in Abrams' "Design and Control of Concrete Mixtures," and supply a basis for our Requirement (4), the law of the optimum fineness modulus for any given cement content and maximum size of aggregate.

Consistency of Concrete and the Slump Test

The plasticity, fluidity or workability of cement mortar, cement-sand mortar, and of concrete, as affected by the water content of the mix, has been called "consistency," with various loose meanings and standards of determination. "Normal consistency" of cement mortar is obtained by a standardized procedure of mixing, manipulation, and determination by penetration with the Vicat needle; the water content is that which produces a paste in the initial state of plasticity and cohesion; and this mixture of cement and water, so determined, averages closely to that having the greatest density of cement solids, or the greatest weight, in a unit volume of mortar. The penetration of a needle or metal rod does not function with any reliability with sand-cement mortar and concrete, and normal consistency, in these cases, has been determined by empirical rule and observation. The "relative consistencies" of a given mix of aggregate and cement have been designated as 0.80, 0.90, 1.00 (for normal consistency), 1.10, 1.20, 1.30, etc., indicating relative volumes of water in identical batches of cement and aggregates. There is practical similarity in the plasticity and workability of normal mixtures (relative consistency 1.0), but other "relative consistencies," so called, vary widely in the relative plasticity, fluidity and workability of various mix combinations, and this standard of comparison has been useless, excepting in the normal consistency, which is too stiff for general use.

Cloyd M. Chapman described a test for consistency (See *Proceedings,* A.S.T.M., 1913) employing a tapered circular mold, open at both ends, which was placed larger end down on a glass plate, and filled with the concrete to be tested. The mold was then lifted carefully off the concrete and the settlement of the concrete noted. This gave rise to the "slump test."

Prof. Abrams developed the slump test, employing, first, a cylinder of 6-in. diam. and 12-in. height, and finally, a 4-in. (top diam.) by 8-in. (bottom diam.) by 12-in. (high) truncated cone, now standard. This final development of the slump test has proved to be a simple, thoroughly practical, and adequately accurate means of determining various consistencies of mix, and supplies an essential measure in concrete technology.

Prof. Abrams' co-ordination of his data of cement-aggregate ratio, water-cement ratio, fineness modulus of grading,

(*Continued on Page* 20)

Colored Concrete Roofing Tile Competes with Ordinary Types

Low Production Cost Opens Wide Market for Roofing Unit—Dimensions and Weight of Tile—Daily Production of Machine

THE manufacture of colored concrete roofing tile that will compete in price with types of roofing such as asphalt and wood shingles is an accomplishment that is of major importance to this special branch of the concrete products industry. It is of equal importance to architects and owners of buildings utilizing this type of roofing.

Opens Wider Market

Heretofore the concrete roofing tile, for the most part, has been sold in competition with clay and slate products. In consequence, these three types had a somewhat restricted market in the residential field, since this comparatively expensive roofing material was confined largely to dwelling houses of the better class. Several notable exceptions have been developed, where concrete roofing tile has been marketed at prices intermediate between wood shingles and clay tile. The ability to compete with ordinary types of roofing has now opened a much wider market for this product.

Type and Dimensions of Tile

The illustration here shown is that of an English style interlocking concrete shingle tile that is produced on a power machine designed for mass production. The individual tile measures 15 by 9¼ in. and the exposed surface when the tile is in place measures 12 by 8½ in. The tolerance, or variation, in dimensions is only 0.010 of an inch, plus or minus. The same machine produces a half tile, which has a surface exposure of 12 by 4¼ in. This machine, in fact, produces any style of tile and it also produces various surface textures.

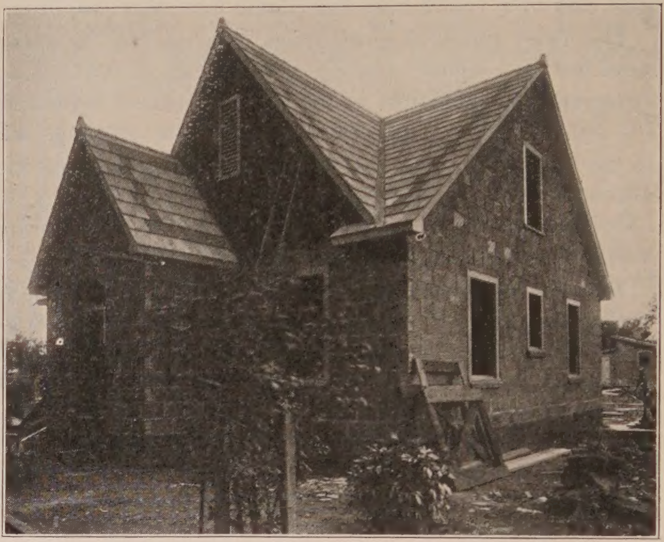
The interlocking concrete shingle type of tile just mentioned weighs from 560 to 750 lb. per square, depending on the aggregate used. Two nail holes are placed in each tile during the manufacturing operation.

Price Lower Than Shingles

Although several roofs were applied a year ago, the roof in the illustration was placed recently. The true and uniform appearance of the tile is well demonstrated in this picture. As the builder expressed it, the tile "fits like the paper on the wall." This contract, though taken at a price that allowed a reasonable profit, was actually less than competitive bids for roofs of wood or asphalt shingles.

Mass Production Responsible

It is, perhaps, only through mass production that colored concrete roofing tile can be produced at a cost low enough to compete on the basis described. The machine that produced this tile, for instance, has a capacity of 150 units per minute, or 450 squares per day of 8 hours. The machine is automatic, requiring only one man for its operation. The tile were not handled by workmen except for stacking them in the yard. In the manufacturing operation the aggregates and cement were weighed and conveyed to the mixer, which in turn was discharged into the hopper which feeds the machine.



English style of interlocking concrete shingle tile competes in price with wood and asphalt shingle roofs

Acknowledgment

The machine that produced the tile here described was manufactured by Otto Walter, Perrysville, Indiana, who has spent some 2½ years in its development.

Using Waste Road Slabs for Rip-Rap

Waste concrete slabs from Route 4, in Illinois, which is being widened, resurfaced and straightened between Springfield and Auburn, will be used by the city of Springfield for rip-rapping road and bridge grades in the Lake Springfield area. While the concrete available from the Route 4 project will not provide all that will be needed, it will save the city a considerable sum. The only cost to the city is that of hauling the concrete.

Date Set for 1933 Meeting of A. S. T. M.

An early announcement issued by the American Society for Testing Materials indicates that the 1933 annual meeting will be held June 26 to 30, at the Stevens Hotel, Chicago, Ill.

EDITORIAL

Railways Beginning to Use Highways

AN editorial in the May issue of "Concrete" pointed out the trend in thought among high railway officials who visualized the establishment of a nationwide motor trucking service as an adjunct to railway freight service.

In view of this trend, the editorial explained, state and county highway departments should put forth every effort to keep up the normal pace in highway construction, and they should also build so-called secondary roads of pavement types that will support motor truck traffic.

The development of this new thought in transportation may require some years for its full growth, but it has not been long in getting started. Recently several railroads, acting through the Railway Express Agency, inaugurated an inter-city express trucking service between Milwaukee, Chicago and South Bend. Thus another commercial use of highways has been born as a result of the demand for quick and direct delivery. The operation of this new service will be watched, and it may soon become national in its scope.

Highway departments can not afford to ignore these trends when establishing their general policies. Neither can highway engineers afford to ignore them in connection with the more specific task of selecting types of construction, for a road that is now classed as secondary may be called upon at any time to carry primary traffic.

Types of construction that are capable of supporting motor truck traffic are the only types that should be given consideration, either for secondary or primary roads.

Road Building Continues in Pennsylvania

THE men who are behind organized efforts to stop the raids on gasoline tax and automobile license funds may take courage from the victory won in Pennsylvania.

In that state, at least, these special highway construction funds, which are a direct tax on the motorist, will continue to be used for building roads instead of being diverted to unemployment doles. Following a state-wide protest against such diversion of highway funds in the amount of 12 million dollars, the legislature adopted a general sales tax of one per cent, applied to nearly all commodities. Thus the tax load is distributed evenly, instead of placing the entire burden of unemployment relief on the shoulders of motorists.

The most encouraging feature of all is seen in the fact that highway construction actually constitutes relief of unemployment—a fact which state legislators have been slow to see.

Unduly Severe Requirements for Winter Concreting

AT this season it again becomes necessary to caution architects and engineers against the temptation to write unnecessarily severe and costly requirements into specifications covering concrete work in cold weather.

Usually one form of this unnecessary severity is found in the provision requiring coarse aggregates to be heated, a process that is costly and of little benefit. Another is the provision that establishes some arbitrary period, such as ten days, during which the concrete must be kept warm. Such a provision often adds unnecessary cost because in many cases a much shorter period would be adequate. The trouble arises from the fact that the length of time is determined from the wrong basis.

Specification writers, as well as men who are charged with the supervision of concrete construction during cold weather, are urged to read the editorial "Sensible Requirements for Winter Concreting," in the November (1931) issue of "Concrete," which in turn refers to an abstract of an article written on this subject by two engineers who have had extensive experience in cold weather operations.

In the matter of heated materials these engineers have found from experience that when outside temperatures are not lower than 15 deg. F. only the mixing water needs to be heated—to a temperature of 180 to 200 deg. F. For temperatures ranging from 15 deg. above zero F. to 40 deg. below, their practice requires the heating of the water and the fine aggregate only, except that in the colder parts of this temperature range they use a steam jet or a kerosene-burning torch in the mixer. The coarse aggregate is never heated.

The period of time during which the concrete in ordinary structures is kept warm depends on the requirements in each case. The protection is removed when samples stored in the inclosure have attained the full designed strength, regardless of whether that period is ten days or three days.

Unduly restrictive requirements in connection with cold weather concreting work will not only discourage winter construction from the standpoint of cost, but they will also incur the antagonism of the contractor. Sensible requirements will stimulate winter construction and gain co-operation from the contractor.

PROGRESS—In a Page

Current activities in research, in matters pertaining to concrete and cement, as being carried on or completed by various organized groups.

Separate and Merged Sessions Planned for Detroit Congress

ON the first three days of the Highway and Building Congress, to be held in Detroit the week of January 16, 1933, separate meetings of the individual associations taking part will be held. Thursday, the fourth day, will be devoted to highways, and Friday, the final day of the Congress, to building and general construction.

By such an arrangement of programs each participating association will retain its individual identity, conducting its usual convention program in its separate meetings on the first three days.

All will merge individual aims in staging the programs of the highway sessions on Thursday, and the building and general construction sessions on Friday. On these two days addresses relating to general highway and building problems will be presented by outstanding leaders.

Two exhibits of equipment and materials will feature the congress. One embracing highway and building construction and maintenance equipment and materials will be staged in the Municipal Airport Building, and the other presenting equipment and materials of special interest to material producing groups, will occupy space in the Book-Cadillac Hotel.

The principal objective of the congress will be to focus public attention upon the economic advantages of highway and building activities. Attempts will be made to solve many of the problems and difficulties general to all groups. Efforts will be directed toward plans for coordinating the financial, contractural, engineering, material and equipment interests of which the highway and building industry as a whole is composed.

Current Activities of Committee on Concrete and Aggregates

A. S. T. M. COMMITTEE C-9 on Concrete and Concrete and Concrete Aggregates has more than 100 items listed in its docket of current activities.

The subcommittee on strength tests has studies in progress on methods of capping, on loading beams, and a method of measuring cores drilled from a concrete structure. A suggested standard test method for permeability and the standardization of test methods for absorption are active projects of the subcommittee on permeability. The subgroup on aggregates has more than twenty items listed, including studies of soundness, abrasion, and light-weight types. Standardization work involves tests to ascertain the amount of soft and rotten particles, specific gravity, and alternate mortar test for sand. The subcommittee on extraneous substances in concrete is working on the effect of mica in sands, effect of organic matter and oil bearing aggregates, and a standard color solution.

The subcommittee on admixtures is developing a method of measuring unit weight and the normal consistency of these materials. A standard method of test for determining volume changes in concrete is being worked up by the group covering elasticity and volume changes. The subcommittee on durability has several items to forward, including the development of test methods for measuring durability and the method of making freezing-and-thawing tests. A proposed method for this latter project was appended to the annual report of Committee C-9, presented at the recent A. S. T. M. annual meeting. Consideration is being given by a subgroup to proposed tentative specifications for ready-mixed concrete.

Officers elected at the recent meeting of the committee include, for chairman, R. W. Crum, director, Highway Research Board, National Research Council; vice-chairman, Stanton Walker, director, Engineering and Research Division, National Sand and Gravel Association; secretary, R. R. Litehiser, chief engineer, Bureau of Tests, Ohio State Highway Department.

Autoclave Test Not Satisfactory for Concrete Aggregates

AMONG the various methods for testing the durability of concrete aggregates, those which are generally conceded to give the most reliable indications require too much time to permit their general use.

In the hope of developing a shorter method, the U. S. Bureau of Standards, acting in conjunction with the Bureau of Public Roads, has tried out the value of the autoclave test for this purpose. This test is sometimes employed as a soundness test for cement.

The tests, as applied to various kinds of aggregate, are described on pages 58-59 of Technical News Bulletin No. 182, June, 1932, published by the Bureau of Standards, Department of Commerce, Washington, D. C.

The results of the tests indicate that the autoclave test, in which the pressures are built up and released slowly, does not offer much promise of being a satisfactory method for testing the soundness of aggregates.

Preserving Cast Stone

A PROCESS for preserving cast stone has been developed and patented (German patent No. 369,807, granted June 10, 1931), by H. R. S. de La Roche, 135 Parkallee, Bremen, and C. Mathies, 27 Grimm, Hamburg, Germany, according to an item in the September (1932) issue of *Concrete Building and Concrete Products* (London).

In applying the process, magnesium oxide is mixed with a filler and with calcium carbonate, moistened with a solution of magnesium chloride, sulphate, or the like, and after setting the surface is treated with a solution of a water-soluble fluoride.

Proportion Aggregate for Concrete on Basis of Separate Sizes

May Use Various Combinations of Assorted Sizes—Special Application in Field of Ready-Mixed Concrete

By G. W. HUTCHINSON
Concrete Consultant, Raleigh, North Carolina

> ***The writer was interested in an article in "Concrete" for May, giving a digest of highway engineering opinion regarding the use of several sizes of coarse aggregate in concrete.***
>
> ***This movement started about 1922, in Delaware. Some engineers laughed at the writer for spending time on such an idea, while two nationally known engineers, along with some others, expressed favorable opinions but felt that it was considerably ahead of the times.***
>
> ***The time is probably coming when all concrete will be proportioned in this manner. Certainly no ready-mixed plant, or any job of appreciable size, can fail to be benefited. The hard part is to overcome the inertia and get the managements of ready-mixed plants to sell high-class concrete that will expand their business instead of just a concrete that will pass until they are forced to do better.—The Author.***

IT is somewhat gratifying to observe that the trend in the proportioning of aggregate for concrete is taking a decided turn toward the use of separate sizes, which are combined in definite amounts to make up a batch of any given size. Surveys recently made (CONCRETE, May, 1932, pages 11-12) have indicated an appreciation of the advantages to be gained when such method is used. It must be admitted that any improvement along this line is certain to provide a more economical and uniform concrete.

Until vigorous promotion of the water-cement ratio law was undertaken, students occupying various and sundry positions had no single basis upon which to design their mixtures. Those who have followed the industry during the past 15 to 20 years have encountered innumerable theories and practices. Despite the criticism of some, there has, without doubt, been merit to many; and an analysis would probably resolve many of the different characteristics to a basis where they would be coincidental with the water-cement ratio law.

Water-Cement Ratio Law Is Practical

Many have felt that the water-cement ratio law has its shortcomings. This may be true, but such objections have, by this time, been considered more of academic than of practical nature. The past recalls intricate formulas which, if followed, would exclude concrete from its major fields. Fortunately, but little is now in evidence, and the exponents of such formulas have been gradually relegated into oblivion.

The binding material of concrete, regardless of the selection of the raw materials and the control during manufacture, is portland cement and always will be. Such improvement as has been, or will be, made from time to time is a matter entirely confined to this single ingredient of concrete. Its effect upon the concrete will be traced to this ingredient and not to its combination with the aggregate as regards practical usage.

Wrong Basis of Analysis

So much stress has been placed upon the quality and upon intricate methods of test of the individual materials that, at times, one is led to believe that when this is accomplished and recorded in the laboratory the troubles are over and the concrete in the field is of assured quality.

It seems that concrete is analyzed by the process of combination rather than by elimination. Many investigations have been carried on in which several variables have been present. The conclusions have been faulty on this account, and when applied to practice, have made a costlier structure. On the other hand, the field testing of concrete, regardless of the care used in the preparation of the specimens, has not yet reached the stage where it can be considered consistent with the concrete composing the mass. Fortunately, the tendency is to obtain lower average results in the laboratory than in the field, but uniformity and strict economy suffer.

Aggregate in Assorted Sizes

Aggregate has been classified in two ways—fine and coarse. Recently movements have been made to abolish this orthodox method and, in a guarded manner, the use of several sizes of aggregate is being advanced. Regardless of the gradation or classification of the aggregate, it is still aggregate when it occupies its place in the finished concrete. Its effect upon the properties of the concrete depends upon the amount of the various sizes which go to make up the total. It is composed of a range in size from that passing the No. 100 sieve to the maximum. The science of proportioning rests upon the amount of each individual size and its relation to the other sizes present. The division of sizes must be carried on with regard to a mathematical screen scale, and the lesser the range between the minimum and maximum screens for each size, the greater the uniformity. With an assortment of sizes, composing aggregate from fine to coarse, an absolute control of the mass is assured and the greatest benefits are obtained from the water-cement ratio method of design.

The gradation of the aggregate affects the amount of water necessary to bring the concrete to a given consistency, and, therefore, reacts upon the water ratio. As the water content is increased to make the consistency wetter, the mixture leans toward segregation. Greater variation from the average strength is obtained, and the practical advantage of the water-cement ratio law becomes less. By suitable division and classification of the various sizes of aggregate, and their recombination in definite amounts, the limits to which the consistency may be made wetter without undue segregation are increased.

Overcoming Segregation During Shipment

In projects of any appreciable size, a saving is encountered when the method is used. Inexpensive screens are mounted either over or beside the proportioning bins and the separated aggregate is conveyed directly to the bins immediately after separation. This allows a greater deviation in many ways in the material as shipped or received, and eliminates the faults due to segregation of the aggregate during transit.

Using Sizes Available

Charts may be made of the various combined gradations which will produce concretes of equal strength, in order that changes may be made without harmful effect for the purpose of using such surplus of given sizes that may be received. An example of such charts is given in a paper published by the American Concrete Institute, 1925 *Proceedings*, "Proportioning Concrete Materials with Especial Reference to Highway Construction," in which the triaxial diagram is used and contours platted for concretes of equal strengths. Other unpublished data by the writer indicates that such methods may be used to include the entire range of the total aggregate used. Further details of the advantages of this method of proportioning have been available from time to time, including the specifications, Patent No. 1,724,403, which covers the method of separation and recombination of the aggregate immediately prior to use.

The modern ready-mixed concrete plant will find such a method a necessity if a guaranteed product is to be obtained. Recent plants erected by leading producers in Pennsylvania and Maryland are among those who have used this method, and it is felt that as the appreciation of uniform and economical concrete of any desired quality is made obvious, the result will be a turn toward regulation and closer control in practice rather than a too strict interpretation of quality in terms of the laboratory.

Railways Ship Bulk Cement in Covered Hopper Cars

Several railway companies have, in recent months, converted some of their hopper cars, originally built for the shipment of coal, into covered hopper cars for the shipment of bulk cement.

The cars are unloaded by gravity. The special unloading equipment required is of a simple character and may readily be adapted to the facilities at hand for the receipt of cement in many concrete products and ready-mixed concrete plants, and at concrete mixing plants on large construction projects.

Cement is discharged underneath the car through four hopper outlets. The most simple arrangement to enable a purchaser of cement to receive shipments in bulk consists of a screw conveyor placed under the rails. Space for the screw conveyor is provided by separating two ties by a greater distance than usual, and excavating the space between ties. The screw conveyor carries the cement to the boot of the bucket elevator, or to whatever facilities the purchaser may have for filling his bulk cement bins.

A slice bar, made from a ¾-in. pipe, flattened and spread at the end, is employed to start the flow if the cement has become packed during transit.

Railway hopper car equipped for shipment of bulk cement

The illustration shows a typical hopper car used in the shipment of bulk cement. Railways which have inaugurated this service include the Lehigh Valley, the Baltimore & Ohio, the Pennsylvania, the Delaware, Lackawanna & Western, the Lehigh & New England, the Reading Railroad and the Jersey Central.

PERSONAL

W. J. Giryotas has organized and become general manager of the Great Lakes Testing Laboratories, located in the Engineering Building at Chicago and engaged in engineering inspection and the making of accompanying tests.

He recently concluded eight years' association with the Robert W. Hunt Co., Chicago. He joined the firm as assistant to the manager of the cement and concrete department, and for the last two years was manager of sales.

R. E. Withrow has organized a company bearing his name engaged in the waterproofing of concrete, masonry and steel. The firm is also in a position to do contracting, supply supervision, and make investigations. It is located in the Rockefeller Building at Cleveland, Ohio.

Mr. Withrow is the former technical manager of the Medusa Portland Cement Co.

O. A. Malone, 51, president of the California Stucco Products Co., Los Angeles, passed away August 24 at his home in that city, after a short illness.

Mr. Malone was well known for his work with colored portland cement stucco textures. For some years he traveled throughout the country giving demonstrations before groups of architects, in co-operation with the Portland Cement Association.

Stress Analysis of Reinforcement in Concrete Pavements

Highway Engineer Makes Comparative Analysis of Cold-Drawn Steel Wire and Structural Grade Bars for Slab Reinforcement

By W. W. ZASS
Engineer of Construction, Arkansas State Highway Commission, Little Rock, Ark.

THE particular merits of cold-drawn steel wire or hot-rolled billet bars as reinforcement in concrete pavement are not susceptible of exact analysis, but by assuming certain conditions a comparison of the effectiveness of each under the varying conditions of the forces encountered may be approximated.

Effect of Change in Moisture Content

Changes in the moisture content of the slab affect the concrete only, and therefore stresses are induced in the steel owing to the concrete expanding or contracting while the length of the steel remains constant. Research and investigation indicate that the probable maximum expansion or contraction of concrete from changes in moisture content approximates 0.0001 in. per inch of length. As the modulus of elasticity of any material is equal in value to the unit stress divided by the unit deformation under such stress, it is apparent that the unit stress causing the unit deformation above cited would evaluate the modulus of elasticity multiplied by the unit deformation. Considering the value of the modulus of elasticity of the reinforcement at 30,000,000 lb. per sq. in. and the maximum coefficient of expansion or contraction of the concrete due to moisture changes at 0.0001 in. per in. of length, a stress is induced in the steel of 30,000,000 x 0.0001, or 3,000 lb. per sq. in. The stress so induced is small, and in relation to the yield point of the steel it is negligible; but it should be considered in a complete analysis of the subject.

When Cracks Are Formed

As steel and concrete expand and contract equally with variations in temperature, no stresses are induced in the steel from changes in length of the pavement slab from such temperature variations. When, however, the slab contracts sufficiently, from either thermal or moisture changes, or a combination of both, to overcome the tensile strength of the concrete, and a plane of rupture or crack is formed, a stress may be induced in the reinforcing owing to a tendency of the adjacent slabs to contract further and thus pull apart from the crack already formed. For the extreme stress transmitted to the steel under this condition a further assumption is necessary in that the stress transmitted to the steel from this movement of the slab stresses the steel only throughout the length required to obtain a satisfactory bond between the concrete and the steel, which length is commonly assumed as 40 times the diameter of the reinforcing member. The antithesis of this condition would result when the stress so transmitted stresses the steel throughout the entire length of the reinforced slab analyzed. Either condition will provide for a comparison of the stresses involved, the former condition involving the maximum and the latter involving the minimum stress transmitted to the steel.

Application to Cold-Drawn Steel Wire

A reinforcing mesh composed of No. 3 gauge, $\frac{1}{4}$-in. diameter, cold-drawn steel wire members having a modulus of elasticity of 30,000,000 lb. per sq. in. and a yield point of 65,000 lb. per sq. in. will be considered. With these values a resultant unit deformation may occur in the steel, as the result of being stressed through adjacent slabs contracting and pulling away from a crack, in the amount of 65,000 divided by 30,000,000, or a deformation of 0.0022 in. per in. of length. If this unit deformation takes place only through the length required to obtain a satisfactory bond between the concrete and the steel and such length is considered as 40 diameters each way from the plane of rupture, a total deformation takes place within such length of 40 x $\frac{1}{4}$ x 2 x 0.0022, or 0.044 in., which would provide for the opening of the crack in such width before the yield point of the wire is used. Considering a pavement slab 50 ft. in length, free at each end and cracking in the middle, and taking the value of the coefficient of expansion or contraction of concrete due to thermal changes as 0.000005, each degree of temperature change will produce a movement of each slab at the crack of 0.000005 x 12.5 ft. x 12 in., or 0.00075 in. If each slab contracts in this amount per degree of temperature change, an opening of 2 x 0.00075, or 0.00150 in., is formed per degree of temperature change. Therefore, the temperature change that would cause the contraction of the concrete and the consequent elongation of the steel in the vicinity of a plane of rupture or crack in the slab, and stressing the cold-drawn steel wire to its yield point, would amount to the total deformation of the steel divided by the deformation in the adjacent slabs per degree of temperature change, or 0.044 divided by 0.00150, or a temperature change of 30 deg. This value would be but slightly reduced if the stress induced in the steel because of moisture changes in the concrete were evaluated, the 3,000-lb. stress as previously computed being deducted from the allowable value of the yield point susceptible to stressing from thermal changes, or the coefficient of expansion or contraction of concrete of 0.0001 due to moisture changes from which the 3,000-lb. stress was computed, being deducted from the unit deformation of the steel computed on the basis of a yield point of 65,000 lb. per sq. in.

Application to Structural Grade Mesh

A reinforcing mesh made up of members of ¼-in. diameter bar steel, structural grade, having a modulus of elasticity of 30,000,000 lb. per sq. in. and a yield point of 33,000 lb. per sq. in. will also be considered. Using these values, as well as the assumptions previously reviewed, a unit deformation of 33,000 divided by 30,000,000, or 0.0011 in. per in. of length is obtained, providing for a total deformation within the length required to obtain a satisfactory bond between the concrete and the steel of 40 x ¼ x 2 x 0.0011, or 0.022 in. With a movement of the adjacent slabs of 0.00150 in. per degree of temperature change, the consequent change in temperature required to stress the bar steel to its yield point would amount to 0.022 divided by 0.00150, or a temperature change of approximately 15 degrees.

It is quite probable that either cold-drawn steel wire or bar steel will resist stresses induced by temperature changes in excess of those developed by this analysis—30 degrees and 15 degrees respectively—before the yield point of the material is reached; but it is also logical to presume that the ratio of temperature change required to stress either material to its yield point as developed in this analysis will remain constant.

As the limit of elasticity of either type of material closely approximates its yield point, it is apparent that a permanent deformation or distortion or failure to recover under release of load will occur more quickly or with less change in temperature conditions with bar steel than with cold-drawn steel wire. Until such permanent set or failure to recover under release of load occurs, the use of either bar steel or cold-drawn steel wire should prove equally acceptable. When such limit is passed, further deformation progresses rapidly and not in proportion to the load applied, and the steel fails to function as a tension member in controlling stresses induced through temperature and moisture conditions.

Simplified Control of Ready-Mixed Concrete

(*Continued from Page* 9)

It must be remembered that it is impossible to keep concrete aggregate constant in gradation, or to keep the moisture constant. Therefore it is useless to run the controls closer than the probable error already in the materials.

How Moisture Changes Are Handled

This method of operation requires a man in charge who has a good knowledge of concrete and its consistency. It does not require that the moisture in the aggregates be continually determined, because if the aggregate has more moisture than assumed the concrete would be too wet. Some of the water would then be left out of the next batch, and aggregate would be added to replace the water left out, thereby keeping the yield constant. Likewise, if more water is added than is allowed in order to produce the required slump, then aggregate will have to be left out, so that the yield may be kept constant. It is important that the aggregate be kept damp before going to the mixer, for this will eliminate the problem of absorbed moisture.

This method of control is based on the assumption that a laboratory with proper equipment will work out charts No. 1 and No. 2 for each combination of materials, determine the specific gravity of the coarse and fine aggregate, and also prepare the necessary tables and instructions for the operation.

Co-ordination of Basic Principles of Concrete Mixtures

(*Continued from Page* 13)

and strength and slump of concrete for various maximum sizes of aggregates, provided the first method of predetermining proportions for concretes of any practicable strength and consistency, employing fine and coarse aggregates of various characteristics in size and grading. However, the employment of the dry-rodded bulk volume, as the basic measure of aggregates, renders the method impracticable to all but the most advanced concrete physicists; and the method provides for only two sizes of aggregates, fine and coarse. Converted to the absolute volume basis of proportions, and co-ordinated with a principle of grading three or more aggregates, it becomes the acme of practical and scientific proportioning methods. See "Co-ordinated Laws of Concrete Mixtures and Their Application," CONCRETE, November and December, 1931.

Errors in September Installment. Several unfortunate errors appear in the September installment of this series. In Equation (14) the expression a/c should be shown as an exponent of N. Likewise, in Equation (15) the expression s/c should be an exponent of Q, and in Equation (17), n should be the exponent of (d/D). In Equation (20), the figure 2 should be shown as an exponent of the expression $\left(\frac{c}{1-s}\right)$.—*The Editors.*

(*To be continued*)

Coming Conventions

October 3-7—National Safety Council, twenty-first annual congress. Washington, D. C.

January 16-18—National Crushed Stone Association, sixteenth annual convention. Book-Cadillac Hotel, Detroit, Mich.

January 16-23—Highway and Building Congress. First annual meeting. Detroit, Mich.

January 17-18—National Sand and Gravel Association, seventeenth annual convention. Book-Cadillac Hotel, Detroit, Mich.

January 18—National Ready-Mixed Concrete Association, third annual convention. Book-Cadillac Hotel, Detroit, Mich.

February 20-23, 1933—American Concrete Institute, twenty-ninth annual convention. Chicago, Ill.

June 26-30—American Society for Testing Materials, annual meeting. Stevens Hotel, Chicago, Ill.

HOW TO DO IT

✦ Questions and Answers ✦
Consultation and Comment

A department devoted to the solution of problems encountered in concrete work. Readers are welcome to add to or improve upon the suggestions printed and to submit their views for possible publication.

Prevention of Air Bubbles on Ornamental Products

We are trying to make a few pieces of garden furniture, such as vases, in connection with our regular concrete block manufacturing business, but we are troubled with the formation of small air bubbles on the outside surface of the product next to the mold. Can you suggest a possible cure for this trouble?—S. C. Co., Minneapolis, Minn.

Ordinarily, air bubbles forming against the face plate of a products mold can be largely eliminated through one of several methods. For instance, the mixture may be made more plastic by reducing the proportions of aggregate, but maintaining the same relation between fine and coarse aggregate, and also leaving the water-cement ratio unchanged.

Another plan, usually more effective, is to vibrate the mold as the concrete mixture is being placed and for a short period immediately after placing. Several power-driven vibrators designed for this purpose are on the market.

Calcium Chloride as an Admixture in Concrete

Please give me your opinion regarding the use of calcium chloride as an admixture in concrete in general construction work, the effect that it has on the concrete mix, and the quantity that may be used.—T. R. W., Long Beach, Calif.

Calcium chloride is used in general concrete construction work (1) mixed integrally in concrete to promote satisfactory conditions for proper curing, (2) mixed integrally in concrete to accelerate the setting of the cement.

When mixed integrally for structural concrete, either for curing or acceleration, inasmuch as it does both, the amount used is 1½ or 2 lb. per sack of cement, according to the temperature. Calcium chloride, however, should never be placed into the mixer in solid form, but should be dissolved and used in the mixing water.

The usual practice is to dissolve 100 lb. of the calcium chloride in a few gallons of water, adding sufficient water to bring the total amount to 25 gal. Then each quart of the solution contains 1 lb. of the calcium chloride. The amount of mixing water used should be reduced by the amount of solution added; that is, if you are using 6 gal. of mixing water to the sack of cement, it will be necessary to use but 5½ gal. of clear water along with a ½ gal. of the calcium chloride solution, which would include 2 lb. of the calcium chloride.

Calcium chloride is used to a considerable extent during low temperatures. The acceleration in the setting of the concrete caused by the calcium chloride increases the temperature of the mass and is a factor in offsetting the effect of low temperatures. However, just as much precaution must be taken to protect the concrete; the use of the calcium chloride acts to reduce the length of time this protection is required.

The value of calcium chloride as a curing agent is the acceleration in the setting of the concrete and in its ability to attract and hold some of the mixing water until it is needed for hydration of the cement. It then releases the water gradually, thus giving the water up as it is needed to provide for continued hydration of the cement.

Doubtless you are familiar with the use of calcium chloride, both integrally and as surface applications, for curing of concrete roads and street pavements.

Mixture for Watertight Foundations

What proportions are usually recommended for watertight concrete foundations in undrained soil, where the building has a basement?—J. F. R., Milwaukee, Wis.

The recommended mix for watertight foundations is one containing not more than 6½ gal. of water per sack of cement. Use a trial batch containing 2½ cu. ft. of sand and 3½ cu. ft. of gravel or crushed stone. If aggregates are moist, use only 5 gal. of water; if they are wet, use only 4¼ gal. Proportions of aggregates may be varied to give a workable mix, one which can be placed readily in the forms without separation of ingredients. This means there should be sufficient cement-sand mortar to give smooth surfaces, free from honeycombing. To insure watertightness, sometimes two or more coats of 1:3 portland cement mortar are applied to the outside surface as soon as the forms are removed.

Tests of Reinforced Concrete Arch Ribs

I am unable to locate a report on certain tests of reinforced concrete arch ribs, made at a university several years ago. Can you give me information about such tests?—E. R. F., Columbus, Ohio.

Tests of the type you describe were made at the University of Illinois, Urbana, Ill., by Prof. Wilbur M. Wilson. Reports of these tests have been published as Bulletin No. 202 (1929) and Bulletin No. 226 (1931) of the Engineering Experiment Station of the University of Illinois. The price of Bulletin No. 202 is given as 55 cents, while Bulletin No. 226 is sent free on request.

New Books and Pamphlets

New Edition of Turneaure and Maurer

PRINCIPLES OF REINFORCED CONCRETE CONSTRUCTION. Fourth edition, revised and largely rewritten. By F. E. Turneaure and E. R. Maurer. Published by John Wiley & Sons, Inc., New York, 1932. Cloth, 461 pages, 6 by 9 in.; many tables, diagrams and illustrations. Price $4.00.

Compared with the previous edition of this book, some of the more important changes seen in the fourth edition include revised formulas and diagrams for the design of beams; formulas and diagrams for design of circular sections subjected to bending and compression; adaptation of diagrams to varying values of *n*; discussion of recent tests on beams and columns; amplification of material on flat slabs, including detailed treatment of footings; more adequate analysis of continuous beams; application of the slope-deflection method to building frames; application of method of moment distribution to continuous girders and frames; detailed analysis of the arch, with methods of arriving at tentative designs; torsional stresses in beams; and the effect of shrinkage and plastic flow on stresses in beams, columns and arches.

Concrete Pipe Culverts

CONCRETE PIPE CULVERTS, published as Bulletin No. 12 of the American Concrete Pipe Association, is a well illustrated 24-page pamphlet containing, among other features, a report of a condition survey of 186 reinforced concrete pipe culverts in Pennsylvania, New Jersey, Delaware, Maryland, Washington and British Columbia.

Other features include the determination of the hydraulic capacity of concrete culverts, determination of the proper size of pipe, and details of precast concrete head walls. Modern methods of constructing concrete pipe culverts in open cut, in tunnels, and by jacking through fills, are also described.

Tests of Centrally Mixed Concrete Transported in Agitator

TESTS OF CONCRETE CONVEYED FROM A CENTRAL MIXING PLANT, by Willis A. Slater, late research professor of engineering materials, Lehigh University, is a 16-page 6 by 9-in. bulletin published as Circular No. 74 by Lehigh University, Bethlehem, Pa. The bulletin is a reprint from the 1931 Proceedings of the A. S. T. M., and gives the results of tests conducted by the author, with the assistance of Inge Lyse.

The concrete involved in these tests was transported, for a period of 2½ hours, in an agitator type conveyor.

1932 Standards Yearbook

STANDARDS YEARBOOK, 1932. Compiled by the Bureau of Standards, U. S. Department of Commerce, Washington, D. C. Cloth, 394 pages, 6 by 9 in. Price $1.00.

The standardization movement in various fields of industry, including cement and concrete, is presented in this book. It outlines the standardization activities and accomplishments of the Bureau of Standards, various other agencies of the federal government and states, counties and municipalities, as well as those of technical societies and trade associations.

ORGANIZATIONS

AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS; W. C. Markham, Executive Secretary, 1222-24 National Press Building, Washington, D. C.

AMERICAN CONCRETE INSTITUTE; Harvey Whipple, Secretary, 641 New Center Building, Detroit, Mich. Twenty-ninth annual convention, Feb. 20-23, Chicago, Ill.

AMERICAN CONCRETE PIPE ASSOCIATION; M. W. Loving, Secretary, 33 West Grand Ave., Chicago.

AMERICAN ROAD BUILDERS' ASSOCIATION; Chas. Upham, Engineer-Director, National Press Building, Washington, D. C.

AMERICAN SOCIETY OF CIVIL ENGINEERS; Geo. T. Seabury, Secretary, 33 West Thirty-ninth St., New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS; C. L. Warwick, Secretary-Treasurer, 1315 Spruce St., Philadelphia, Pa.

ASSOCIATED GENERAL CONTRACTORS OF AMERICA; E. J. Harding, Managing Director, 222 Munsey Bldg., Washington, D. C.

BUILDING OFFICIALS CONFERENCE OF AMERICA; Col. John W. Oehmann, Secretary, 1253 Lawrence St., N. E., Washington, D. C.

CAST STONE INSTITUTE; L. A. Falco, Secretary, Chapel St. and Blatchley Ave., New Haven, Conn.

CEMENT INSTITUTE; Luther G. McConnell, General Manager, 11 East 44th St., New York City.

CONCRETE MASONRY ASSOCIATION; Jack Franklin, Secretary, 7071 Plankinton Bldg., Milwaukee, Wis.

CONCRETE REINFORCING STEEL INSTITUTE; M. A. Beeman, Secretary, 333 North Michigan Ave., Chicago.

ENGINEERING INSTITUTE OF CANADA; 2050 Mansfield St., Montreal, Quebec.

HIGHWAY RESEARCH BOARD; Roy W. Crum, Director, 2101 Constitution Ave., Washington, D. C.

JOINT COMMITTEE ON STANDARD SPECIFICATIONS FOR CONCRETE AND REINFORCED CONCRETE; F. R. McMillan, Secretary, 33 West Grand Ave., Chicago.

NATIONAL BOARD OF FIRE UNDERWRITERS; W. E. Mallalieu, General Manager, 85 John St., New York City.

NATIONAL CONCRETE BURIAL VAULT ASSOCIATION; J. H. Stuart, Secretary-Treasurer, Bremen, Ohio.

NATIONAL CRUSHED STONE ASSOCIATION; J. R. Boyd, Secretary, 1735 14th Street, N. W., Washington, D. C. Sixteenth annual convention, Jan. 16-18. Book-Cadillac Hotel, Detroit, Mich.

NATIONAL ENGINEERING INSPECTION ASSOCIATION; B. H. Witherspoon, Secretary, P. O. Box 1115, Pittsburgh, Pa.

NATIONAL FIRE PROTECTION ASSOCIATION; Franklin H. Wentworth, Secretary, 40 Central St., Boston, Mass.

NATIONAL LIME ASSOCIATION; Norman G. Hough, Secretary and Manager, 927 Fifteenth St., N. W., Washington, D. C.

NATIONAL READY-MIXED CONCRETE ASSOCIATION; V. P. Ahearn, Secretary, 545 Munsey Building, Washington, D. C. Third annual convention, Jan. 18. Book-Cadillac Hotel, Detroit, Mich.

NATIONAL SAND AND GRAVEL ASSOCIATION; V. P. Ahearn, Executive Secretary, 545 Munsey Bldg., Washington, D. C. Seventeenth annual convention, Jan. 17-18. Book-Cadillac Hotel, Detroit, Mich.

NATIONAL SLAG ASSOCIATION; H. J. Love, Secretary-Treasurer, 937 Leader Bldg., Cleveland, Ohio.

NATIONAL TERRAZZO AND MOSAIC ASSOCIATION; U. F. Durner, Secretary, 815 West St. Paul Ave., Milwaukee, Wis.

NORTHWEST CONCRETE PRODUCTS ASSOCIATION; W. P. Hews, Secretary-Treasurer, Yakima, Wash.

PORTLAND CEMENT ASSOCIATION; Edward J. Mehren, President; William M. Kinney, General Manager, 33 West Grand Ave., Chicago.

RAIL STEEL BAR ASSOCIATION; H. P. Bigler, Engineering Secretary; Builders' Bldg., 228 N. La Salle St., Chicago, Ill.

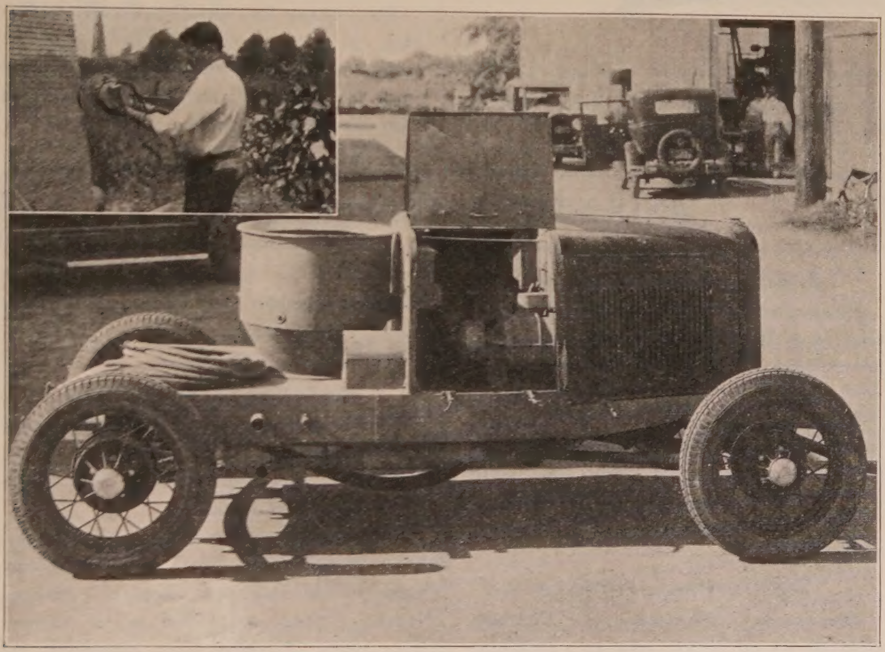
WIRE REINFORCEMENT INSTITUTE; R. D. Bradbury, Director, National Press Bldg., Washington, D. C.

WISCONSIN CONCRETE PRODUCTS ASSOCIATION; Jack Franklin, Secretary-Treasurer, 425 East Water St., Milwaukee, Wis.

New Equipment and Materials

West Coast Develops Rotor-Mix Concrete Placing Method

The Rotor-Mix is California-developed equipment for placing concrete by gun and air pressure. It mixes and throws the material by an electrically driven rotating wheel set in the light-weight, hand-operated gun. The nozzle man has complete remote control of the entire machine, the flow of material, and the water ratio, according to an announcement by the Welded Products Co., Bell, Calif.



The Rotor-Mix equipment consists of a special assembly of generator, blower, water pump and open material hopper, all driven by a 4-cyl., governor-controlled gas engine and compactly mounted with the power unit on a rubber-tired trailer chassis which may be towed and steered from either end. Materials placed in the hopper are conveyed to the air stream and through a flexible hose to the mixing and placing nozzle.

The water pump driven direct from an engine take-off shaft by V-belts is said to assure constant volume and pressure.

The open hopper has a capacity of 500 lb. and with its conveyor and agitator drives assures a continuous flow of materials without the necessity of operation of covers, lids or valves while loading. The hopper top is low enough to allow easy accessibility for charging by shoveling or dumping.

General Motors Introduces Engine, Two Trailers

Two new trailers, providing greater carrying capacity with less chassis weight, have just been announced by the General Motors Truck Company. These models are the TT-252 semi-trailer with a payload capacity of from five to ten tons, and the TT-418 four-wheel trailer, with a three to five ton payload rating.

The engine is a 6-cyl. unit of 400 cu. in. displacement, developing 296 ft. lb. of torque over a speed range of from 800 to 1600 r.p.m. and 112½ brake h.p. at 2800 r.p.m.

Locking is accomplished automatically when coupling, while a pull on the lever is all that is necessary to uncouple. Flexibility is assured by a universal G. M. T. lower fifth wheel which compensates for a difference in elevation of about 2 ft. between the truck and trailer wheels which is more than will ever be encountered in any trailer operation. Coupling even at right angles is possible. Two heavy springs on the lower fifth wheel absorb coupling shocks and prolong the life of both truck and trailer, it is stated.

The engine is said to develop greater torque and horsepower per cubic inch of displacement than any other truck engine in its class.

Through this high torque maintained over a wide speed range, marked economy of operation is effected, less gear shifting is required and greater performance is obtained, it is claimed.

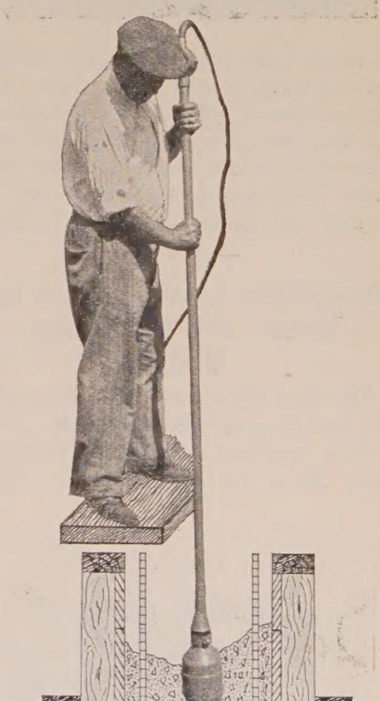
Vibro-Spade Is New Aid to Concrete Placement

The Vibro-Spade is the newest addition to the Jackson line of Vibro-cast equipment for concrete placement to be manufactured by the Electric Tamper & Equipment Co., Ludington, Mich.

Mixes drier than can be handled by the usual methods can be placed, without rock pockets, or honeycombing, it is claimed.

Use of the Vibro-Spade is especially suggested in placing concrete in walls, piers, buttresses and other reinforced sections.

Hand spading is eliminated and the forms are undisturbed, the puddling action taking place within the mass of concrete.



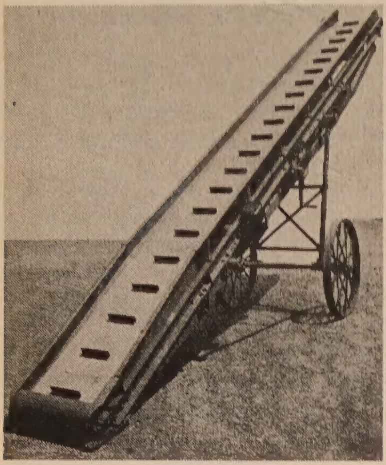
This method of internal compaction at the same time obviates the use of heavier form construction.

One man can puddle the output of a ½-yd. mixer, according to the Electric Tamper company. The operator is said to receive no shocks, the patented rubber core absorbing all vibrations.

Portable Belt Conveyor Announced by Link-Belt

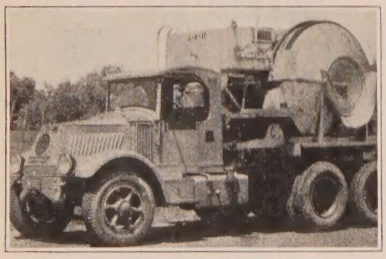
Fixed steel retaining sides extending the entire length of the conveyor is one of the features of the improved Link-Belt company portable belt conveyor.

The foot end has also been improved to keep material away from the return run of the conveyor belt to obviate a common source of trouble experienced with portable belt conveyors of this general type. Another feature is the new arrangement of the foot end plate, permitting the convenient use of the machine without this plate, when desired, minimizing labor in feeding, and serving to speed up loading.



Contractor Uses Chassis for Mixer, and for Dump Body

The eleven Mack model AK, six-cylinder, six wheelers recently delivered to B. Perini & Sons, prominent contractors of Framingham, Mass., are versatile units — dump trucks one day, concrete mixers the next.

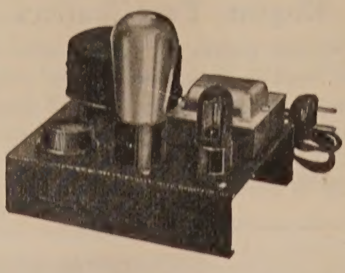


As earth movers they average 11 yards to the load. When concrete is ready to be poured, the dump bodies and hoists are easily removed and 5-yd. Jaeger mixers mounted on the chassis, as shown.

Uses of Foto-Switch in Concrete Plant

The Foto-Switch is announced by the G-M Laboratories, Inc., Chicago, as a new, low-cost photo-electric relay for the control of all types of electrical devices. These include motors, signals and alarms. The unit may be used as a limit switch, as a bin level indicator or control, and for regulating the flow of sand and gravel.

The device embodies an electro-magnetic switch which is opened or closed by the interruption or variation in the illumination on the photo-electric cell.



Improvements on Dragline Buckets Are Announced

Notable improvements have been made in its dragline buckets, according to the Harnischfeger Corp., Milwaukee, Wis.

Made in sizes from ⅝ to 4 cu. yd. capacity, P&H dragline buckets are of combination riveted and welded construction, giving ample strength with minimum weight.

The bucket shell is built up of heavy tank steel. The bottom and sides are cut from a single piece, with the back welded into position. A heavy strip of steel is welded around the upper edge of the bucket to give it additional strength.

The cutting lip, which is readily renewable, is an exceptionally heavy piece of forged boiler plate extending well up the sides of the bucket and securely fastened with countersunk rivets.

INDUSTRIAL LITERATURE

Kosmos Super Cement

Kosmos Super Cement is thoroughly covered in a 16-page booklet just issued by the *Kosmos Portland Cement Co.,* Louisville, Ky. Contents are conveniently arranged, each page containing full information on a single page. Charts clarify and emphasize special points. Index tabs facilitate reference to the various divisions.

Copies will be sent if requested.

Toledo Proportioning

The *Toledo* method of proportioning concrete by weight is described in a loose-leaf booklet by that name issued by the *Toledo Scale Co.,* Toledo, Ohio.

Its contents include moisture determination, compensation for surface moisture in batching, weighing of all aggregates, cement and water, graphic record for inspection, specific gravity determination, and sieve analysis.

The Huggenberger Tensometer

A new 12-page bulletin *No. 37* has just been issued by *Baldwin-Southwark Corp.,* Philadelphia, covering the line of lever type strain gauges known as *Huggenberger tensometers.*

A short technical discussion of the fundamental principles of these instruments is followed by detail data and suggestions concerning application of the various types of tensometers. Fixing devices which are necessary in the application are fully described and illustrated. A section describing the methods of mounting and using tensometers and fixing devices concludes the booklet.

The Huggenberger tensometer is a multiplying lever device for measuring the strain in a specimen under load and thereby the stress in the specimen.

Requests for bulletin No. 37 will be granted promptly by Baldwin-Southwark Corp., Philadelphia.

Redesigned Scale Line

The Kron Co., Bridgeport, Conn., is now distributing a new bulletin describing its completely redesigned line of Kron automatic industrial scales.

Included among the scales described and illustrated are dial track scales, portable pan, portable platform, dormant platform, bench, hopper, crane and pitless suspension types. All have been completely redesigned, improved and strengthened and the dial and lever mechanism considerably simplified, it is stated.

Manufacturers' News

Two-Ply Stainless Steel

Following the recent announcement of the Ingersoll Steel & Disc Co., Chicago, that they had perfected and patented a commercially successful two-ply stainless steel, comes the more recent news of the consummation of a license agreement with the Allegheny Steel Co. of Brackenridge, Pa., by which the latter will manufacture two-ply stainless steel sheets exclusively under the patents of the Ingersoll company.

Tricosal New York Office

The Tricosal Products Company, Inc., manufacturers of concrete waterproofing, quick-setting and quick-hardening materials, has established eastern offices at 11 West 42nd Street, New York.

The plant and head offices of this organization are located in Seattle, Wash.